Coastal Engineering Technical Note

USE OF GABIONS IN THE COASTAL ENVIRONMENT

PROGRAM PURPOSE: To describe the use of gabions in the coastal environment as a form of low-cost shore protection.

BACKGROUND: Gabions are rectangular steel wire baskets. When filled with stone, they can help protect areas experiencing erosion due to waves, currents, or groundwater flows. Gabions can also be used to reduce wave runup and overtopping. Care should be exercised, however, in using gabions in a high energy wave environment.

As depicted in Figures 1 and 2, gabions come in various sizes and configurations, depending upon application.

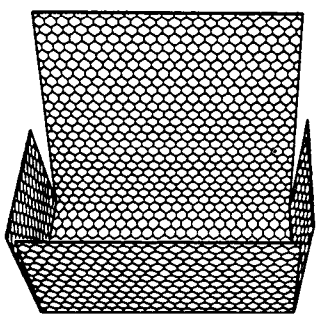

Figure 1.
Gabion without diaphragms.

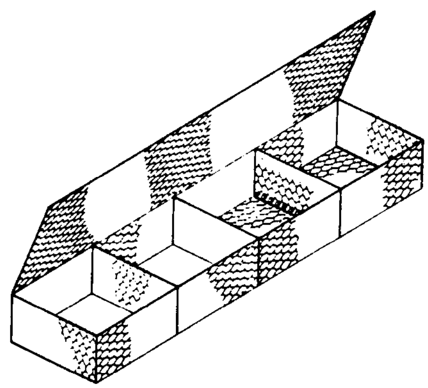

Figure 2.
Gabion with diaphragms.

Gabions were first used over 75 years ago in Italy on river projects. Today, they have a variety of applications such as retaining walls, revetments, flexible aprons, and breakwaters.

Gabions have had limited use in the coastal environment where they are subjected to wave forces and saltwater corrosion. To retard corrosion in salt water, the wire mesh can be galvanized, PVC coated, or both. However, each of these measures has limitations. Galvanized coating may be prone to chipping. PVC coating can be susceptible to wear and cracking, particularly in cold climates.

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GENERAL INFORMATION:

1. Potential Benefits:

A. Low Cost. Gabions can be more economical for shore protection than riprap because they require smaller size stone. Small stone would negate the need for heavy construction equipment. In areas where large stone is not readily available, the use of small stone could mean a substantial cost savings.

B. Ease of Installation. Gabions can be installed without specialized skills or equipment. A crane or front-end loader, to fill the baskets with stone and move them into place, may be the only major equipment required.

Bundles of gabion wire mesh are unfolded at the construction site and assembled by lacing the diaphragms to the side panels and joining the edges together. The diaphragms restrict internal movement of the rock fill and reinforce the structure. Tying the gabion units together vertically and horizontally provides structural strength and integrity. Failure to tie the gabions together may cause premature structure failure. Bedding and filter material, such as geotextile fabric or gravel, should be placed between the soil foundation and the gabions to function as an underlayer and to provide adequate subsurface drainage without leaching. Toe protection is also important. Use of additional quarrystone to act as toe protection should help prevent scour problems.

Once in place, the gabions are ready to be filled with stone. The gradation should be uniform and sufficiently large to prevent individual stones from being washed through the wire mesh. The stone should also be small enough to facilitate even placement with minimal void space. Major stone movement or loss would cause gabion deformation and eventual rupture of the wire due to abrasion. The ideal stone for gabion use is rounded, has a high specific gravity, and ranges in size from 12 to 25 cm (approximately 5 to 10 in.), depending on mesh size. It is important to fill the gabions completely with stone, packing tightly to minimize flexing. Some manual shifting of the stones may be necessary for optimal placement and performance. Once the gabions are filled, the lids are tied closed. Tiers or levels can be formed by stacking, filling, and tying the gabions together. The time saved in not lacing the units according to specifications will be offset by shortened structure lifespan.

As an additional design consideration, Brown (1979) proposed an equation for computing gabion thickness in the presence of wave action.

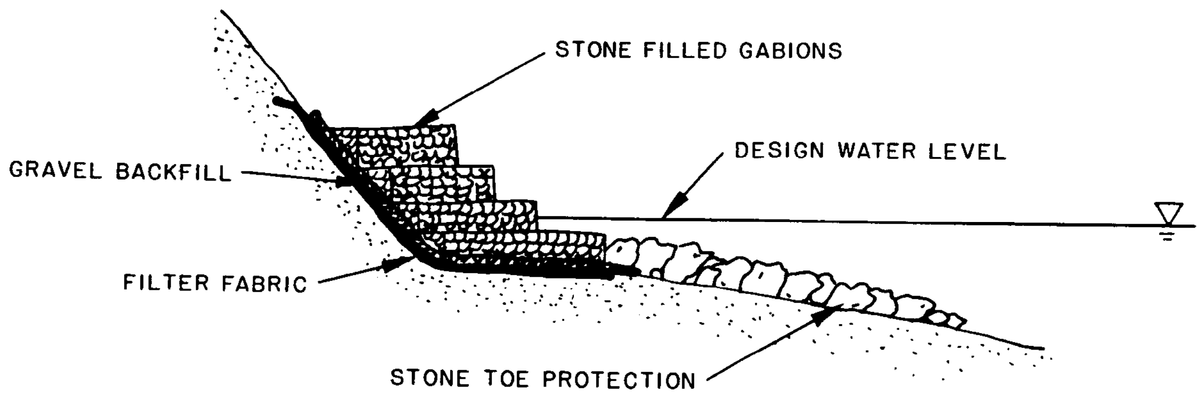

Figure 3. Typical Gabion Installation

C. Flexibility. Gabions can adjust to limited localized stresses induced by small foundation settlement and deflection. When deformed within these limits, the structure should remain intact, maintaining its strength and adapting itself to soil movements.

D. Ease of Maintenance. Simple field maintenance, such as replacing lost stone and repairing damaged wire mesh with new wire, is feasible without the use of heavy equipment. Gabions should be inspected regularly and after storms to ensure that low grade damage is repaired immediately. If conditions change, the structure can be modified by adding or deleting sections.

2. Potential Limitations:
The following is a listing of gabion limitations extracted from performance reports of field applications:

A. Baskets may be difficult to fill completely with stone. When the baskets are not completely filled, flexing occurs, which leads to wire fatigue and eventual failure.

B. The PVC wire coating may be prone to cracking and wear.

C. Structure lifespan is difficult to predict.

D. If caustic chemicals are present in the area, chemical reactions involving the wire are possible.

FUNCTIONAL APPLICATIONS:

1. Kotzebue and Ninilchik, Alaska:

A. Tests involving gabion performance were conducted in Kotzebue and Ninilchik, Alaska, in 1978 and 1979. At Kotzebue, gabions were deployed in a 198-ft-long revetment. The PVC coated gabions were lined with filter fabric and filled with sand. Within a year, the gabions eventually deteriorated from wave attack, debris, and ice forces. (US Army Corps of Engineers 1981)

B. At Ninilchik, Alaska, a tiered gabion groin was constructed to provide toe protection for a timber crib groin. The structure performed well initially, but later failed when the tier levels shifted because the gabions were not tied together. A gabion revetment was also constructed to provide tow protection for a timber revetment, but waves with heights up to 6.5 ft ripped the baskets apart, causing the loss of fill material. Damage may have been facilitated by wire corrosion due to the cracking of the PVC coating (US Army Corps of Engineers 1981). Both gabion structures failed within a year.

C. In both the Kotzebue and Ninilchik tests, the gabion manufacturer's deployment recommendations were not followed fully. The gabion fill material should ideally range in size between 12 and 25 cm. (approx. 5 to 10 in.), but should certainly be larger than the mesh size to prevent the fill from escaping, even when a basket liner is used. The gabions should also be tied together to provide structural strength and integrity.

D. Basket liners should not be used. Although filter cloth was used as a liner in the previous applications to retain the fill material and reinforce the gabions, it may have promoted structural instability by diminishing permeability, thereby reducing the capacity of the gabions to absorb wave energy.

2. Geneva State Park, Geneva, Ohio:

A. A three tiered 100-ft-long breakwater with 4- to 10-in. rock fill was constructed at Geneva State Park, Geneva, Ohio, on Lake Erie in 1979. Filter cloth was placed under two-thirds of the structure to ascertain settlement differences. Structure effectiveness was proven after a full tombolo was created behind and along the length of the structure. However, after a year of direct exposure to wave activity and debris, the gabion wire mesh failed. No significant differences in settlement with or without the filter cloth underlayer had occurred by that time.

3. Cape May Canal, New Jersey:

A. Cape May Canal, located at the mouth of Delaware Bay on the Atlantic Ocean, was the site of another gabion structure. Erosion by ship generated waves necessitated some form of bank protection. In December 1982, 1500 ft of galvanized and PVC coated gabion revetment was installed utilizing a stepped slope for increased wave energy dissipation. Gabion rock fill ranged in size from 10- to 20-cm. (approx. 4- to 8-in.). A 10- to 13-cm. (approx. 4 to 5 in.) thick filter underlayer with crushed stone was also used.

B. The project performed well with minimal maintenance. Failure from flexing because the baskets were not initially tied to the embankment resulted in the slight loss of fill material from baskets at the revetment ends.

DISCUSSION: In summation, gabions may be useful for certain applications in the coastal environment. However, there are some critical points to consider.

1. When deciding whether to use gabions, an assessment must be done to consider the economics associated with their use versus the risks if failure occurs.

2. Gabions should not be used in high energy wave environments.

3. Gabions should not be used in the active surf zone or where large amounts of debris are present.

4. Gabions should not be used on public beaches where injury to bathers from protruding wire is possible.

5. The manufacturer deployment recommendations should be adhered to unless there is a sound engineering reason for modification.

6. After installing gabions, a comprehensive inspection and maintenance plan should be established.

ADDITIONAL INFORMATION: Contact Ms. Joan Pope (601) 634-3034 of CERC Coastal Structures and Evaluation Branch.

REFERENCES:

Brown, C.T. 1979. "Gabion Report on Some Factors Affecting the Use of Maccaferri Gabions and Reno Mattresses for Coastal Revetments," Report No. 156, University of New South Wales, Water Research Laboratory, Manly Vale, N.S.W., Australia.

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